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BEFORE THE U.S. SENATE COMMITTEE ON APPROPRIATIONS
SUBCOMMITTEE ON AGRICULTURE, RURAL DEVELOPMENT,
AND RELATED AGENCIES

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Mr. Chairman, thank you for the opportunity to submit testimony on economic issues related to biofuels. My statement will briefly discuss the current situation in the biofuel industry and prospects for growth.

Since the energy crisis of the 1970s, developing new energy sources from the agricultural sector has been viewed as a way to expand the domestic energy supply and help mitigate our growing dependence on imported oil. Including hydropower, renewable energy accounted for six percent of U.S. energy consumption in 2004, with energy from biomass contributing almost half of that total. Biomass energy is primarily produced from wood (70 percent) followed by waste (20 percent) and alcohol fuels (10 percent). While wood has provided most of the biomass energy over the years, ethanol has been the fastest growing renewable energy source over the past 10 years. Ten years ago, ethanol's share of biomass energy was less than 4 percent.

Corn Ethanol and Biodiesel

While the growth in U.S. ethanol production has been impressive in recent years, ethanol still accounts for only a small portion of U.S. gasoline use—just 3 percent of total annual consumption. However, ethanol's economic importance to agriculture is quite significant. About 14 percent of the U.S. corn crop was used for ethanol in 2005/06 and USDA projects nearly 20 percent of U.S. corn production will be converted into ethanol in 2006/07. Clearly, the supply of corn is relatively small compared with U.S. gasoline demand, so other domestic sources of renewable energy must be developed to replace oil if the United States is to greatly reduce its dependence on imported oil. Biodiesel, which has grown more rapidly than ethanol in recent years, can extend the U.S. supply of diesel fuel, but the supply of oil crops, animal fats, and other biodiesel feedstocks are also relatively small compared to the size of the overall diesel fuel market. There is optimism that research may provide technological breakthroughs that lead to a significant expansion in ethanol produced from alternative biomass feedstocks. Ethanol's feedstock base could expand significantly with the advancement of technologies that economically convert switchgrass and other low-valued biomass into cellulosic ethanol.

The Current Ethanol Market

In 2000, about 1.6 billion gallons of ethanol was produced in the United States. By 2005, about 4 billion gallons of ethanol was produced, a 150 percent increase in 5 years. In 2006, nearly 5 billion gallons of ethanol is expected to be produced, a one-year increase of 20 percent. There are now 101 ethanol plants with total capacity of 4.8 billion gallons operating in 20 states. The Renewable Fuels Association reports that there are 39 ethanol plants under construction and another 7 facilities expanding with total capacity of 2.6 billion gallons per year. When that construction and expansion is completed, ethanol capacity in the United States will be 7.4 billion gallons per year.

A number of factors have contributed to the rapid increase in production, including the 51 cent per gallon tax credit provided to blenders, high and volatile oil prices, low corn prices, the Renewable Fuels Standard (RFS) under the Energy Policy Act of 2005, and the elimination of ethanol's main oxygenate competitor, methyl tertiary butyl ether (MTBE).

Another factor supporting ethanol expansion has been generally improving production economics. Ethanol production costs declined between 1980 and 1998. Technology improved over this period leading to: (1) a higher yield of ethanol per bushel of corn, (2) a lower cost of enzymes required for conversion, and (3) production automation which lowered labor costs. Energy input costs also fell over this period. Department of Agriculture (USDA) surveys indicate that between 1998 and 2002 the average cost of producing ethanol (excluding capital costs) remained unchanged at about 95 cents per gallon. In 2002, higher energy costs were offset by lower labor and enzymes costs. Since 2002, the cost of production has increased by 10 to 15 cents per gallon due to the increased cost of energy (electricity and natural gas). Hence, USDA estimates that the current average cost of ethanol production is about $1.10 per gallon.

Various industry analysts suggest that there are another 60 or more ethanol plants under different stages of planning, and these plants are in addition to those currently under or approved for construction. The expectation is that production capacity could rise well above the current 7.4 billion gallons level of plants that are now operating or are under expansion or construction. New facilities under construction or in development tend to be large, with production capacity in the range of 50 to 100 million gallons per year. Ethanol production capacity could increase to 7.5 billion gallons by 2008-9 and more than 10 billion gallons by 2012.

Ethanol production in 2006 through May has been running at an average of 12.4 million gallons per day. As additional facilities come on line, production is expected to rise steadily throughout the year and total 4.9 billion gallons for the year.

While there is significant euphoria about the current and future prospects for ethanol, there are risks in the outlook. The major uncertainty is how the market will evolve over time if production of ethanol stays above the levels mandated by the RFS. There is no requirement for use to rise above 7.5 billion gallons at this time, and for use to exceed 7.5 billion gallons, ethanol must be competitive in the market place. A combination of declining gasoline prices, sharply rising corn prices, or a decline in the premium ethanol has to gasoline prices could curtail the ethanol production expansion.

An issue that has gained much attention as ethanol production has expanded is the implication for animal feed supplies. While corn used for ethanol does not go directly to animal feed, key ethanol coproducts are animal feeds. About 17 pounds of distillers dried grains with solubles (DDGS) with 13 percent moisture are produced per bushel of corn used for ethanol. Distillers grains are sold one of three ways: wet distillers grains (WDG) with 67 percent moisture, modified distillers grain with 50 percent moisture, or dry DDGS. Generally, dairy feed rations can include up to 40-45 percent DDGS and fed cattle rations can include up to 35-40 percent DDGS. Monogastric poultry and hog rations can include up to 5 percent DDG. DDG include 10 percent fiber that can not be digested by poultry and hogs.

On a nutrient basis, one pound of DDG is equal to about one-half pound of corn and one-half pound of soybean meal. About one-third of the corn used in the production of ethanol is available as a feed in the form coproducts feeds from wet and dry mill ethanol plants.

The Current Biodiesel Market

Biodiesel, which is just beginning to establish a market in the United States, is a biofuel substitute for petroleum diesel. The majority of biodiesel in the United States is made from soybean oil (estimated at over 90 percent), but a few producers use other oilseed crops, palm oil, animal fats and recycled oils to make biodiesel. Biodiesel can be used in most diesel engines, with little modification. Because it has similar properties to petroleum diesel fuel, biodiesel can be blended in any ratio with petroleum diesel fuel and is most often blended at the 20 percent level (B20). Today, most B20 is used by government motor fleets, urban bus fleets, and school buses. It is also been used in farm equipment, marine engines, and furnaces as a replacement for heating oil. The trucking industry has recently showed interest in using biodiesel and B20 is being offered at some truck stops.

U.S. biodiesel production remained very small and flat until USDA created the Bioenergy Program in Fiscal Year (FY) 2000 that encouraged biodiesel production through cash payments to producers. Mostly as a result of this program, biodiesel production jumped from 500,000 gallons in 1999 to 28 million gallons in 2004. In 2005, 91 million gallons of biodiesel were funded by this program. However, the Bioenergy Program authorization ends in FY 2006. Even so, with high diesel prices and new tax incentives, USDA forecasts biodiesel production will reach 245 million gallons in 2006, a 170 percent increase year over year and a 490-fold increase since 1999.

When assessing the cost of producing biodiesel, soybean oil has a higher cost than other feedstocks, but other feedstocks, such as yellow grease and beef tallow, cost more to process. The cost of building a biodiesel plant depends on many factors, including plant capacity, location, plant design, and equipment cost, which varies by the type of feedstock used. A general rule of thumb for estimating the cost of installing a small biodiesel plant is about $1.00 per gallon of annual capacity, thus a 5-million-gallon capacity plant has an estimated installation cost of $5 million. However, due to economies of scale, the installation costs begin to decrease as plant size exceeds about 5 million gallons per year. The processing cost per gallon of biodiesel, including the cost of materials, labor, energy, plant depreciation, and interest is about $0.50 per gallon for a 5 million gallon per year plant. The cost of the feedstock is by far the largest expense for a biodiesel producer. For example, soybean oil at current prices would cost about $1.95 to produce one gallon of biodiesel, resulting in a total production cost (excluding capital costs) of about $2.45 per gallon.

Adding the expected return to investment and the costs for transportation, blending, and marketing would push the expected retail price of 100 percent biodiesel (B100) well over $3.00 per gallon. Until recently, the high cost of biodiesel has made it very difficult for biodiesel to compete in the diesel fuel market. However, with the recent surge in oil prices, diesel fuel prices have risen to historical highs, and biodiesel has become more cost competitive. Moreover, recent legislation has granted biodiesel a $1.00 per gallon excise tax credit and a $0.10 gallon small producer tax credit. Government incentives along with higher diesel fuel prices have made biodiesel production profitable and the industry is now expanding rapidly, much like ethanol.

The biodiesel industry is still in its infancy, so as it grows to a larger scale and when an infrastructure is developed, the costs of producing and marketing biodiesel may decline. New cost-saving technologies will likely be developed to help producers use energy more efficiently, increase conversion yields, and convert cheaper feedstocks into high-quality biodiesel. However, in the longer term, the biggest challenge may be the ability of feedstock supply to keep up with growing demand. The supply of soybeans and other feedstocks available for biodiesel production will be limited by competition from other uses and land constraints. For the 2005/06 crop year, biodiesel production accounted for 5 percent of soybean oil use and for 2006/07, biodiesel is expected to account for 2.6 billion pounds of soybean oil or 13 percent of total soybean oil use. (The 2.6 billion pounds equals the oil extracted from 229 million bushels of soybeans or 8 percent of the estimated U.S. soybean production in 2006.) Therefore, the rapidly increasing demand for biodiesel will tend to push feedstock prices up, causing production costs to rise. Since feedstock cost is the largest component of production cost, it may be difficult for biodiesel producers to keep costs down overtime.

As of April 2006, the National Biodiesel Board indicated there were 65 commercial U.S. biodiesel plants. The annual production capacity of these plants ranges from 200,000 gallons to 30 million gallons, and they have a total capacity of about 400 million gallons. Most plants have an annual production capacity below 6 million gallons. Only 7 plants have an annual capacity above 15 million gallons, however, newer plants currently under construction tend to be larger. The National Biodiesel Board reports that there were 50 new plants under construction as of April 2006 that are expected to add another 700 million gallons to annual capacity. The annual capacity of these new plants ranges between 15,000 and 85 million gallons. Fourteen plants will have an annual capacity over 15 million gallons. Soybean oil is the most common feedstock used for biodiesel production, however, the largest plant under construction that will have an annual capacity of 85 million gallons plans to use canola oil. Plants that use recycled cooking oil are generally smaller with capacity ranging between 15,000 and 1 million gallons per year.

Judging from the capacity that is currently being built by investors, biodiesel production is expected to continue growing rapidly over the next few years. With over 100 plants expected to be on-line by the end of 2007, the biodiesel industry is well on its way to becoming a major provider of renewable fuels. Data on production reported for 2006 through June indicate that about 90 million gallons of biodiesel have already been produced, about equal to 2005's total production. If monthly production were to continue at about the same level achieved in June, total annual production would reach about 200 million gallons by the end of 2006. Thus, compared to 2005, biodiesel production could more than double in calendar year 2006. Growth seems likely to decline as base production reaches a higher level, so biodiesel production is expected to be sharply higher but below 400 million gallons in 2007.

Cellulosic Ethanol

More than 12 billion gallons of ethanol was produced globally in 2005. Ethanol made from sugarcane and starch, such as corn, accounted for 61 and 39 percent, respectively, of the total. Sugar and starch are easy to convert to ethanol. Cellulosic materials such as wood and grasses as well as other types of biomass, such as agriculture and forest residues, animal manure, and organic materials in municipal solid waste could also be converted to ethanol. However, conversion of biomass materials to ethanol is very complex.

Wood and grasses include cellulose, hemicellulose, and lignin. Cellulose and hemicellulose contain 6 and 5 carbon sugars, respectively, and can be converted to ethanol, but the process is complex and costly. Lignin accounts for about one third of the weight of biomass materials and cannot be converted into ethanol. However, lignin has a high BTU content, and, with current technology, can be burned to generate steam and electricity for use by ethanol plants.

There are several processing technologies available to convert biomass to biofuels. Three major processes are: (1) enzymatic hydrolysis, (2) gasification and conversion of synthesis gas to liquid diesel fuel (Fischer and Tropsch process), and (3) gasification and conversion of gas to ethanol with use of some microorganism (Gatty process). The processing technologies to convert biomass to ethanol at the pilot scale are available in the United States, Canada, and Europe. Presently, there are no commercial plants that convert biomass materials to ethanol in the United States or elsewhere in the world. There are four biomass pilot ethanol plants in the United States, Europe, and Canada under construction.

• The U.S. Department of Energy (DOE) is partnering with Abengoa Bioenergy Corporation to build a biomass to ethanol pilot plant in York, Nebraska. Construction of this pilot plant is expected to be completed by fall of 2006.

• Iogen Corporation is teaming up with Royal Dutch Shell to construct a cellulosic ethanol demonstration facility in Ottawa, Ontario, Canada. The feedstock for the demonstration facility is wheat straw, and the plant utilizes Iogen's enzymes to convert the biomass materials to ethanol. Iogen has also indicated plans to build a large-scale biomass ethanol plant either in Idaho Falls, Idaho, or in Canada. This commercial biomass ethanol plant is expected to require a capital investment of over $350 million for a 40-million-gallon annual production capacity plant.

• A pilot plant under construction in Germany (Choren) will convert biomass material to renewable diesel fuel utilizing the Fischer and Tropsch process.

• Abengoa is also building a hybrid biomass starch ethanol plant in Salamanca, Spain. This plant will use barley straw and barley for production of ethanol.

A commercial-scale plant is expensive to build and thus represents a high-risk investment at this point in the technology development. Barley and wheat straw and corn stover are the most likely initial feedstock candidates for cellulosic production of ethanol. Cellulosic ethanol plants may use other energy crops as well, such as switchgrass.

Xethanol has announced plans to construct a 50-million-gallon per year cellulosic ethanol plant in Augusta, Georgia. It is being designed to run on a variety of forest product feedstocks. Xethanol is expected to produce ethanol and co-products using biomass waste feedstocks with technology co-owned by USDA and the University of Wisconsin. Consolidated rights were licensed by the Wisconsin Alumni Research Foundation (the licensing arm of the University of Wisconsin) to Xethanol. The technology, developed by Dr. Tom Jeffries of the USDA Forest Service, Forest Products Laboratory, converts xylose, a 5-carbon sugar, into ethanol and xylitol.

Biomass ethanol today is more expensive to produce than corn-based ethanol. The capital requirement per gallon of biomass ethanol is 5 to 6 times higher than corn ethanol. The ethanol yield is about 100 gallons per ton of corn and 70 gallons per ton of biomass. Biomass to ethanol is a very complex process and requires pretreatment and costly enzymes to convert the 5 and 6 carbon sugars to ethanol.

The cost of enzymes per gallon of biomass ethanol is estimated at 30 to 50 cents per gallon of ethanol, compared with the enzyme cost of corn ethanol of only 3 cents per gallon.

Ethanol concentration in the alcohol solution (called beer) made from biomass is about 4 percent, compared to about 14 to 20 percent for corn ethanol. The costs of harvesting, bailing, storing, and transportation of feedstocks for biomass are also expensive. A consensus among experts at a recent DOE workshop was that the delivered biomass cost to ethanol plants is about $50 per dry ton or about 70 cents per gallon, which is higher than the net corn costs per gallon of ethanol. Also, conference attendees projected biomass ethanol production costs by 2012 at $1.50 to $1.75 per gallon, which compares with $1.10 per gallon for producing ethanol from corn today. The goal of the President's Biofuels Initiative is to get the cost of cellulosic ethanol competitive with corn ethanol by 2012.

Corn ethanol will have an advantage over biomass ethanol in the near future under the existing biomass technologies. It will take continued research and development and time to increase the ethanol yield per dry ton of biomass from 70 gallons to 100 gallons. In addition, research and development is needed to increase energy crop yield per acre and reduce the conversion cost of biomass to ethanol. The Department of Energy is investing in this research and development in its Genomics: GTL program in the Office of Science and in its Office of Biomass programs. In addition, the Department of Energy and the USDA recently announced joint funding for new research projects aimed at improving energy crops.

Longer-term Outlook for Renewable Fuels Production

The recent surge in oil prices has made biofuels much more cost competitive with gasoline and spurred new investment. Ethanol and biodiesel production will continue to expand as long as world petroleum prices remain high. World oil prices have increased sharply since 1999, when the annual average nominal price of West Texas Intermediate (WTI) crude oil jumped from $19.25 per barrel in 1999 to $30.29 in 2000. Between 2000 and 2003, the average WTI price ranged from about $26 per barrel to $31 per barrel. In 2004, the WTI price increased to over $41 per barrel and the 2005 average WTI price increased to over $56 per barrel. DOE’s Energy Information Administration’s (EIA) short-term projections indicate that the average WTI price for a barrel will climb to $69 in 2006 and remain at that level in 2007.

Higher crude oil prices have translated into higher wholesale and retail prices for gasoline and diesel fuel. EIA estimates that the average wholesale price for gasoline increased from $1.28 per gallon in 2004 to $2.04 per gallon in 2006. With average production costs (excluding capital costs) for ethanol at about $1.10 per gallon, ethanol was not competitive with gasoline at 2004 prices without the income tax credit. However, with the recent increase in gasoline prices, corn-based ethanol is competitive with gasoline even without the income tax credit.

Under EIA’s long-term forecast, the real price of imported oil is expected to level-off after 2007 and perhaps show a slight decline by 2010. Nevertheless, world oil supplies are expected to remain tight as the demand for oil remains strong, keeping pressure on oil prices. If future oil prices reflect EIA projections, biodiesel and ethanol production will continue to grow with the rate of growth depending on the level of oil prices, feedstock costs, and changes in technology.

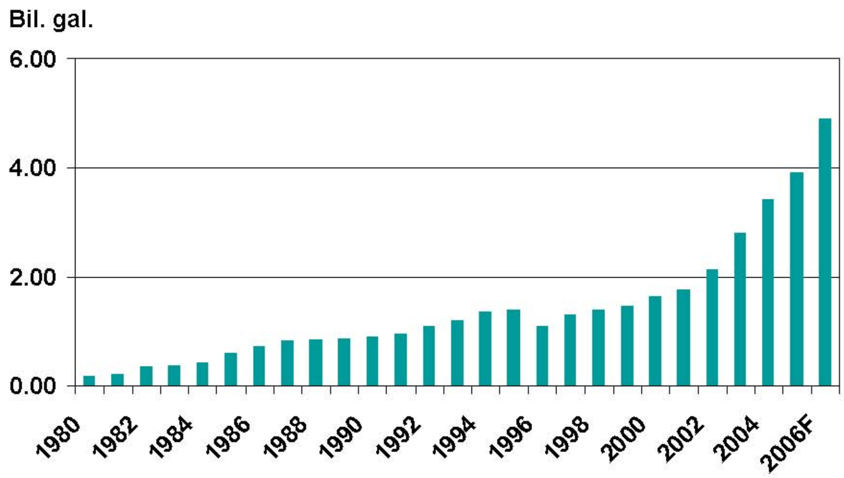
In the longer term, EIA expects domestic energy consumption to continue to grow. By 2030, EIA forecasts that total U.S. energy consumption in the transportation sector will increase by over 40 percent from current levels. For renewable fuels to meet and capture a larger share of the transportation demand for energy, their growth will need to be even more impressive than their recent growth. Combined, ethanol and biodiesel accounted for only about 2 percent of total gasoline and diesel fuel used to meet our transportation needs in 2005. For renewable fuels to meet 10 percent of the energy demand from the transportation sector by 2030, 31 billion gallons of renewable fuels per year would need to be produced. To meet 30 percent of the energy demand from the transportation sector by 2030, 90 billion gallons of renewable fuels per year would need to be produced. To meet 50 percent of our transportation energy demands, renewable fuel production would need to increase to about 160 billion gallons per year.

With the supplies of corn and oil crops small compared with the gasoline and diesel fuel markets, economically feasible biomass feedstocks and conversion technologies are needed to greatly reduce dependence on imported oil. A recent joint USDA and DOE report, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, commonly known as the "Billion Ton Report," projects that there are over 1.3 billion dry tons per year of biomass potential, enough to produce biofuels sufficient to meet more than one-third of the nation's current demand for transportation fuels by 2030. More than 25 percent of this potential would come from extensively managed forestlands and about 75 percent from intensively managed croplands. However, the report further notes that to use a significant amount of these biomass resources would also require a concerted research and development effort to develop technologies to overcome a host of technical, market, and cost barriers.

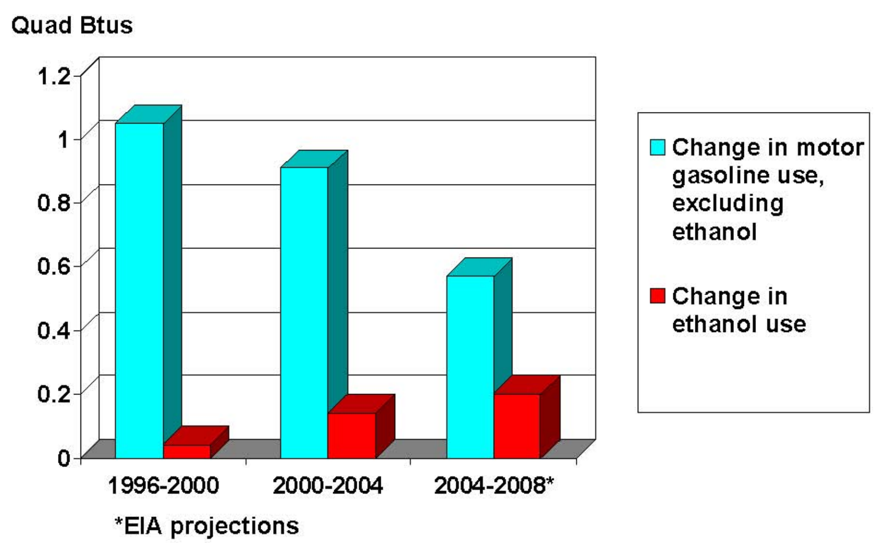
If the world price of crude oil remains higher than $50 (in 2005 prices) per barrel as projected by EIA, then ethanol could be used as a gasoline extender because ethanol would be cheaper than gasoline and demand for ethanol and biodiesel would likely exceed the minimum levels in the RFS. Both corn ethanol and biomass ethanol would be used. It is highly unlikely that prices of crude oil will drop below $30 per barrel. However, below this price, there would be no demand beyond the RFS for either corn or biomass ethanol because ethanol would be uneconomical compared with gasoline.

Mr. Chairman, in addition to the material in this statement, my office recently coordinated a USDA Farm Bill Theme Paper on *Energy and Agriculture* that may provide the Subcommittee added information. The paper is available at www.usda.gov/documents/Farmbill07energy.doc . That completes my statement.

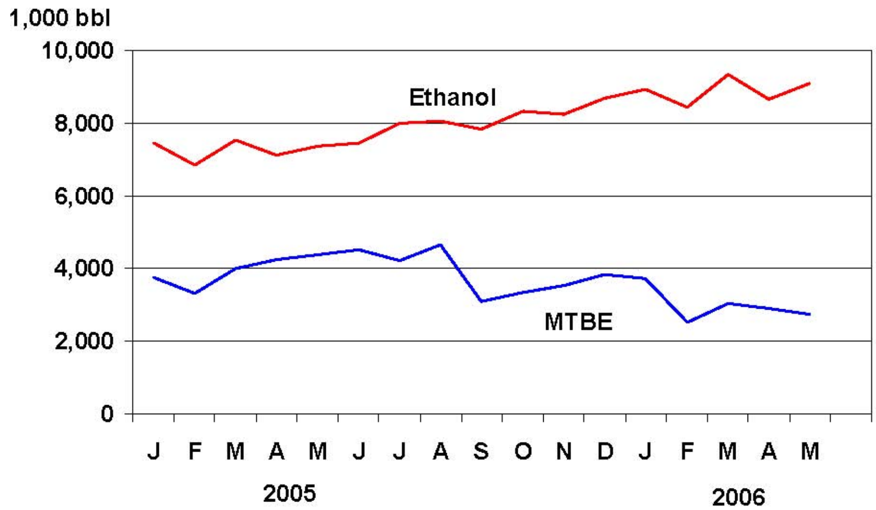
U.S. Annual Ethanol Production



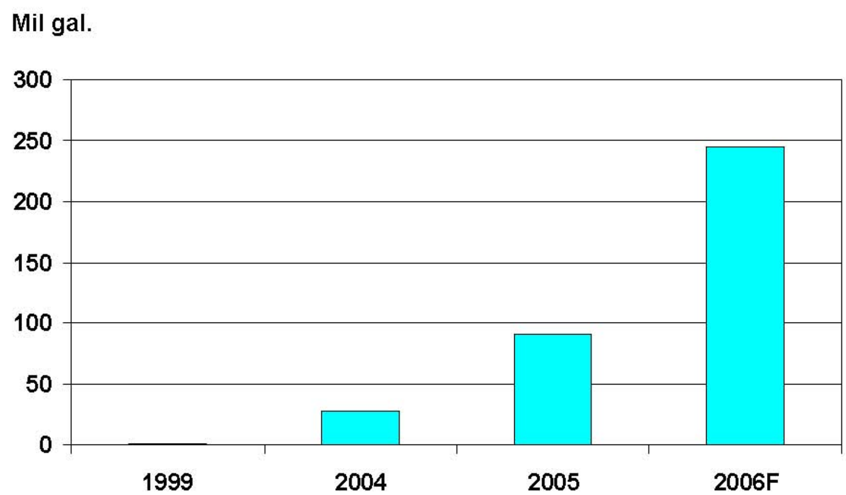
U.S. Ethanol v. Gasoline, Changes in Use,
Over Periods Indicated

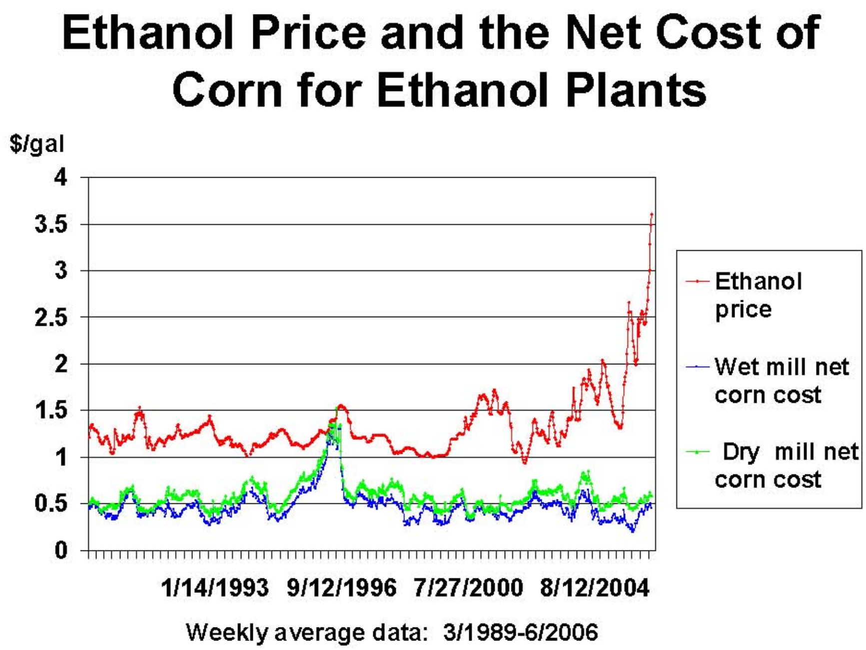


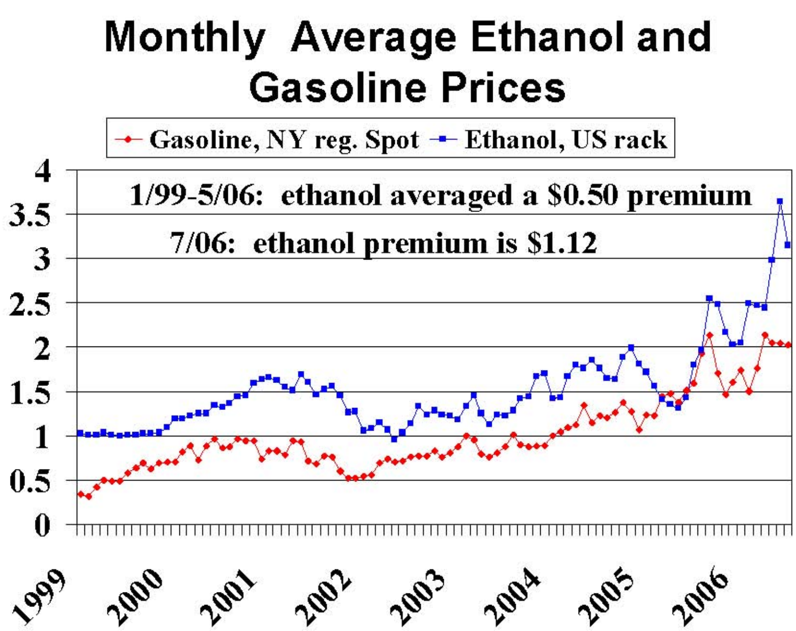
Monthly Ethanol & MTBE Production



U.S. Annual Biodiesel Production



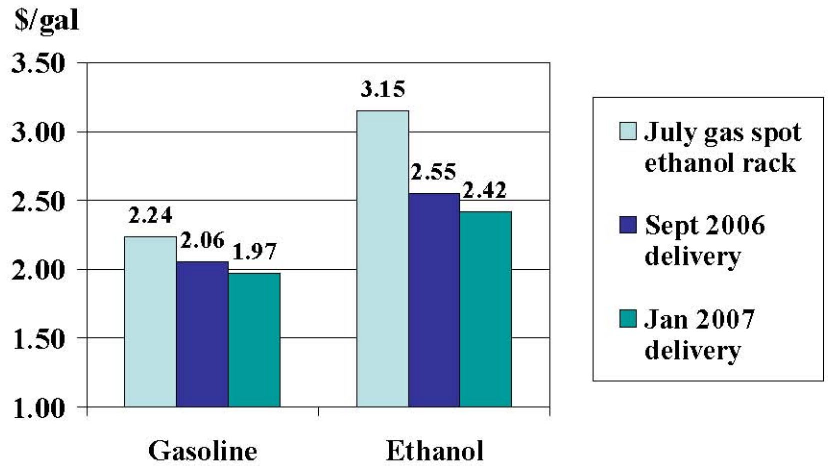

Ethanol Price and the Net Cost of Corn for Ethanol Plants
$/gal
4
3.5
3
2.5
2
1.5
1
0.5
0
1/14/1993
9/12/1996
7/27/2000
8/12/2004
Weekly average data: 3/1989-6/2006
Ethanol price
Wet mill net corn cost
Dry mill net corn cost


Monthly Average Ethanol and Gasoline Prices
Gasoline, NY reg. Spot
Ethanol, US rack
1/99-5/06: ethanol averaged a $0.50 premium
7/06: ethanol premium is $1.12
4
3.5
3
2.5
2
1.5
1
0.5
0
1999
2000
2001
2002
2003
2004
2005
2006

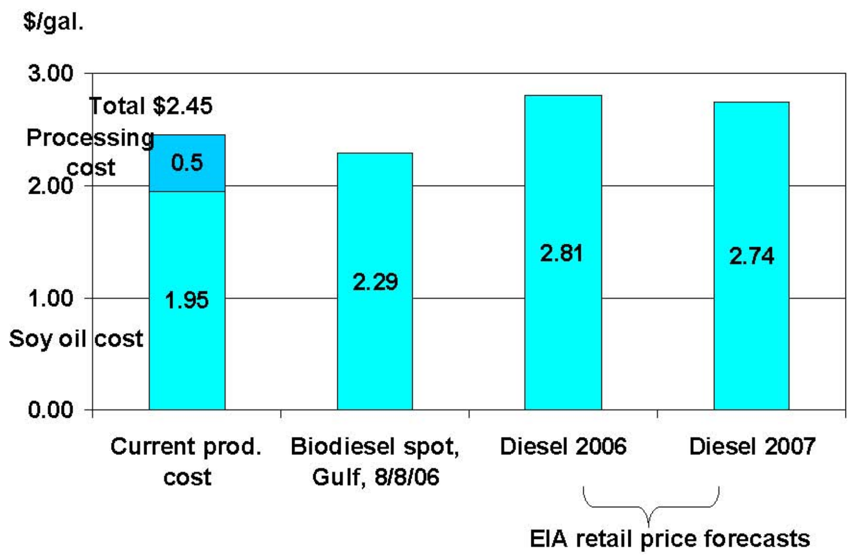
May Spot and Futures Prices,

as of August 11, 2006

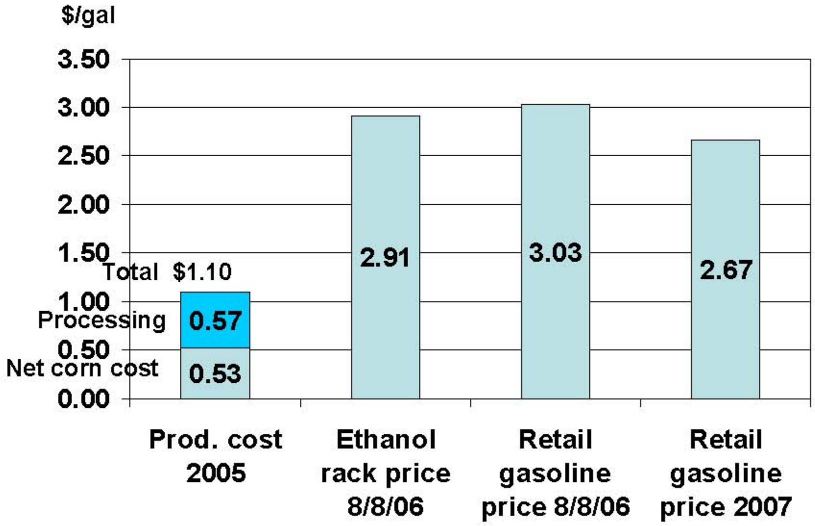
Futures: NYMEX gasoline, CBOT ethanol



Biodiesel Costs and Returns



Ethanol Costs (Dry Mill) and Returns



Current Comparison: Ethanol from Corn v. Cellulosics

	Corn	*Cellulosic materials*
Capital cost to build plant, per gallon	$1.25-$1.50	$4.30 -$5.44
Conversion process	Simple	Complex
Enzyme cost, per gallon	3 cents	30-50 cents
Byproducts	Protein & oil	Electricity
Energy used in processing	Nat. gas & Elec.	Self-sufficient
Alcohol content of beer, percent	14-20	4
Fermentation time, number of days	2	7
Labor use in processing plants	Low	High
Ethanol cost of production, per gallon	$1.10	Up to twice corn ethanol
Ethanol yield per dry ton, gallons	98	70-80
Transportation cost of raw materials	Low	High

Estimates by USDA/OCE from various sources